13.

THE SYNTHESIS OF CATARACT

BY

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In the American Journal of the Medical Sciences for January 1860, there is a paper, by Dr S. Weir Mitchell, on the production of cataract in frogs, by the introduction of sugar into the system. It appears from Dr Mitchell's paper that he arrived at his facts in the following way. He was engaged in performing a series of experiments on the absorption of woorara through animal membranes. A solution of woorara having been enclosed in the stomach of a rabbit, the stomach was placed in syrup for two hours. About two drachms of the syrup were then injected under the skin of a pigeon, but no result indicating the introduction of a poison followed. One drachm and a half of the same syrup was next injected into the subcuticular sac of a frog. The frog died within five hours. An examination of the

syrup having been made, it did not seem that any portion of woorara had been transmitted through the membrane to the syrup.

Why then did the frog die? It occurred to Dr Mitchell, that, as the amount of sugar employed in the case of the frog was very large as compared with the bulk of the animal, the sugar might possibly be destructive to life when used as in the experiment named above.

From this point, Dr Mitchell passed to investigate the effects of sugar on frogs, by injecting syrup in varying quantities into the subcuticular sacs. He was led thus to observe that sugar might really be poisonous under certain conditions, but he was led also to another fact : he was led to discover that a peculiar form of cataract was a constant attendant of the sugar poisoning and was enabled in a manner equally creditable to his own powers of observation, interesting to his profession and useful to the world altogether, to work out, at least in one direction, the "*Synthesis of cataract.*"

I had thought, on reading through Dr Mitchell's paper, that in his labours a discovery entirely original was announced. In so far as he is concerned I am sure the discovery was original, but I find that Kunde, some few years ago, travelled far in the same direction, and in fact established in a different way somewhat a similar synthetical induction.

Having thus far introduced to the reader the pre-existing records on which the following researches have been based, I proceed to the history of certain experiments of my own, bearing upon the whole subject.

EXPERIMENTS WITH SYRUP OF CANE SUGAR.

Exp. I. On March 15th 1860, three drachms of syrup of cane sugar, of specific gravity 1,270, at 60° Fahr., were put into a beaker with one drachm of distilled water. A small frog, the dorsal cuticular sac being laid open by two incisions, was placed in the syrup at 11.30 p. m. Previous to the experiment the eyes of the animal were perfectly clear. After forty minutes immersion, the creature was found, with the head above the solution, breathing regularly, but exhibiting languid movements. The web of each foot was extraordinarily reddened and congested ; the eyes were clear ; at the end of the first hour from the commencement of the experiment, the languid condition had very much increased, and the body was greatly shrunken, there seemed also a redness over the whole surface of the body.

A drachm more of water was added to the syrup. At 2 a. m. of the 6th (i. e. after two hours and a half of the immersion) the langour was such that it was difficult to say whether life continued; but some slight movements were made on excitation : the lens of each eye was now distinctly opaque. The opacity seemed to be general and was of pearly whiteness. At 3 a.m. the opacity was more distinct. The frog was now dead : I removed it from the syrup and placed it in pure water. Returning at 10 a.m. of the 16th, the opacity of the lenses was found to have passed away altogether; and the lenses removed from the eyeball were beautifully transparent.

Exp. II. On March 16th 1860, at 10 p. m., a fish (a minnow) was placed in six ounces of a syrup of cane sugar of a specific gravity of 1,100. At the end of twenty minutes the animal seemed nearly dead, but the syrup being reduced by the addition of water, to sp. grav. 1,050, the fish rallied and recommenced swimming briskly. Fifteen minutes later, it floated on its side and showed no voluntary movements; the syrop was therefore brought, by the addition of more water, to a specific gravity of 1,025, when the creature again rallied and continued to live for the next hour and a half without any embarrassment. There was, at this period, no sign of opacity in the eye. The syrup was therefore raised to specific gravity 1,040. At 3 a.m. of the 17th, five hours after the commencement of the experiment, the fish was swimming livelily about, but the lens on the left side was markedly opaque; the right clear. The animal was obviously blind on the left side. At 12.30 p. m. of the 17th, the same conditions were observed.

Exp. III. At 12.30 p. m. of the 17th, the fish rendered cataractic by the last experiment was removed from the syrup and placed in pure water. In six hours the opacity of the lens had almost entirely passed away. About noon on the next day, the fish, without any obvious reason, died. The lens was still a little opaque, and on removing it, the opacity was found to be situate anteriorly; at the point of opacity there was a slight depression.

Exp. IV. At 7.50 p. m. of March 17th three drachms of syrup of cane sugar, of specific gravity 1,050, were injected from a syringe armed with a fine hollow needle under the skin of a frog in the dorsal region. Soon after the injection the skin became greatly distended from transudation. The animal passed into what seemed to be a profound coma, so that it was difficult to decide when death actually took place; certainly death was perfect in six hours. I think long before. The distention of the body remained. In this instance no appearance of cataract was produced.

Exp. V. An incision was made through the cuticle of a frog on the under surface of the body, and at 8.20 p. m., on the 17th of March, the animal was placed in a syrup of cane sugar of specific gravity 1,060. At midnight the frog showed little desire to move : it was torpid and scarcely excitable by irritants; there was distinct opacity of the lens in each eye. At 6 a. m. of the 18th I found the animal dead with marked double cataract. On removing the lens I found that the opacity was diffused superficially over about a third of the circumference : centrally the lens was clear. This observation extended to both lenses.

Exp. VI. One drachm of syrup of cane sugar, of specific gravity 1,150, was injected under the skin of a frog beneath the dorsal surface, on March 19th, at 8 p.m. At 11 p.m. the animal remained the same : there was no cataract. I placed it in a bed of very moist moss, and in the morning of the 20th found it well. No cataract resulted in this case.

Exp. VII. One drachm and a half of syrup of cane sugar, of specific gravity 1,150, was injected into the subcuticular dorsal sac of a frog on March 21st, at 11.45 p.m. The animal was left in a bed of moistened moss. At 11 a.m. of the 22th, the lenses of both eyes were opaque. The opacity was anterior and extraordinarily marked. It remained for nearly a week, but ultimately passed off.

Exp. VIII. On the same day, at the same hour, one drachm and a half of syrup of cane sugar, specific gravity again 1.150, was injected under the skin of another frog. On the 22nd, at 11 a.m., there was dimness of the lens on both sides, but the effect was very much less marked than in the frog noticed in the last experiment. One drachm more syrup was injected. At 2 p.m., the opacity was intense in both eyes, and the creature was feeble. Ultimately this frog, on being placed in wet moss, recovered, and the lenses became entirely cleared : in six days there was no trace of cataract.

Exp. IX. On March 22nd 1860, at 11.30 p.m. half an ounce of syrup of cane sugar, of specific gravity 1.150, was injected into the peritoneal cavity of a Guinean pig. The injection was made slowly from a syringe armed with a fine hollow needle. At midnight the animal was lively and seemed free from pain. On March the 23d, at 10.30 p.m., 23 hours after the experiment, there was no sign of cataract; half an ounce more of the syrup was therefore injected. In the course of the night I rose once to inspect the animal : it was dull and sleepy; there was opacity posteriorly commencing in the lens of each eye. At 6 on the morning of the 24th the animal was dead : the cataractous condition having become much more marked. The opacity of the lens after death was found most marked posteriorly.

Exp. X. At 11.45 a.m., on March 23rd two drachms of syrup of cane sugar, specific gravity 1,150, were injected into the dorsal cuticular sac of a frog. On the morning of the 24th, at 11, there was marked double cataract. The animal was placed in a position to have free access to water; the opacity disappeared in six days.

Exp. XI. On March 24th, at 8 p.m., one ounce and a half of syrup of cane sugar, of specific gravity 1,100, was injected into the peritoneum of a healthy dog. On the 25th he seemed none the worse : no opacity of the lens was visible. One ounce more of the syrup was injected. From this date to the 29th of March the animal continued the same, when the injection was repeated under chloroform. Unfortunately the animal died suddenly a minute or so after the injection from the effects of the chloroform.

Ten minutes after death I opened the peritoneum. The fluid injected had been nearly all absorbed. The whole of the peritoneal surface was brilliantly injected, and the lacteals were distended with white fluid to an extent I have never before witnessed. The stomach contained no food

nor had any been given for three hours previously to the operation.

Exp. XII. On March 25th two drachms of cane sugar syrup, of specific gravity 1,150, were injected into tho dorsal subcuticular sac of a frog at 7 p. m. At 2 p. m. of the 26th, there was opacity of the lenses of both eyes. The frog was now immersed in water, the water being frequently changed. On the 28th of March the opacity had entirely passed away.

Exp. XIII. The same proceedings as noted in the last experiment were performed at tho same time on another frog. The results were nearly identical; if there was any difference, it consisted in the fact that, at the period of total eclipse of vision, the opacity was not quite so dense as in the case preceding.

Exp. XIV. The experiment as in numbers XII and XIII was repeated on another frog at the same time, under the same conditions, and with the same results as in experiment XII.

Exp. XV. A fourth frog was injected with the same quantity of the syrup as in experiments XII, XIII and XIV. The injection was made in the same way and within ten minutes of the time named in experiment XII. The frog was placed under precisely the same conditions as the other three; but the results were less distinctly manifested. At the period of total eclipse in the first three, this frog could see distinctly, and although there was slight central opacity of the lenses, its duration was short and it was never of sufficient character to attract the attention of any one unprepared for the occurrence.

The above fifteen experiments afford an accurate estimate of the effects of cane sugar syrup. The experiments on frogs were repeated many times, but it were mere repetition to record the more.

EXPERIMENTS WITH GRAPE SUGAR.

Exp. XVI. On March 17th 1860, at 12.30 noon, a fish (a minnow) was placed in syrup of grape sugar, of specific gravity 1,040. At 12 (midnight) the animal was well, swam about livelily and shewed no sign of lenticular opacity. It was allowed to remain in the syrup for two days, but with no further result. Removed now to common water, it died in about 48 hours; the eyes remained quite clear to the end.

Exp. XVII. A frog, the cuticle on the under surface having been opened by two small incisions, was placed in a syrup of grape sugar, of specific gravity 1,150, at 8 p. m. on March 17th. At midnight the motions of the animal were tardy; there was slight central opacity in both lenses. On the morning of the 18th, the animal was found dead, with the lens on each side opaque. On removing the lenses I found the opacity to depend on a superficial cloudiness. The lens removed from the right eye was dim on the anterior part of the circumference; the lens on the left side was dim over the whole circumference; the centre of the lens was clear in each case.

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Exp. XVIII. On March the 18th, at 1.30 p.m., one drachm of grape sugar syrup, specific gravity 1,150, was injected into the subcuticular dorsal sac of a frog. At 4 p.m. the lenses of the eyes on each side were markedly opaque. The opacity was diffused. The frog was very torpid, but could be roused. At 6 p.m. it was dead. On removing the lenses, the left lens was found opaque on the anterior surface only; the right lens presented a generally diffused opacity. In both the centre was perfectly clear on section.

Exp. XIX. On March 18th 1860, one fluid ounce of syrup of grape sugar, of specific gravity 1,150, was slowly injected with the hollow needle into the peritoneum of a healthy Guinean pig, at 4 p.m. Fifteen minutes after the injection the body was distended and there were slight convulsions; the convulsive motions continued, and within the hour death occurred. On opening the peritoneum there were collected from the cavity two fluid ounces of thin straw like syrup: the specific gravity of this fluid was 1,030. The peritoneal surface was injected; the bladder was distended with urine, and the urine carefully drawn off, gave distinct evidences of sugar by Trommer's test; *no cataract was produced.*

In this experiment death was caused too quickly to allow the production of a change so comparatively remote as opacity of the lens. But the experiment has its value as indicating the rapidity of osmotic changes in the body. One fluid ounce of syrup was thrown into the peritoneal cavity; within an hour afterwards two ounces of fluid were there: of necessity the additional ounce was derived from the blood of the animal. But further, the syrup injected had a specific gravity of 1,150, while the fluid removed from the peritoneum had a specific gravity of 1,030, giving a difference of 120 degrees. But I found afterwards by direct experiment that, to produce such a difference in the specific gravity of the syrup, four ounces of fluid were required. In the osmotic current therefore, caused by the sugar injection in this experiment, there must have passed out of the circulation of the Guinean pig, in the course of the hour, three fluid ounces over and above the one additional ounce found after death, with a returning current into the circulation of three fluid ounces.

Exp. XX. On March 19th, at 11 a.m., half a drachm of syrup of grape sugar, of specific gravity 1,150, was injected under the skin of a frog. At 7 p.m. the animal was unaffected, and there was no indication of opacity of the lens. At the last named hour one drachm more of the syrup was injected. The animal was placed in a large glass chamber on the floor of which was a little water, but not more than bathed the web of the feet. The animal seemed to suffer but little; I watched it hourly, but

could never detect a trace of lenticular opacity. It recovered without cataract.

Exp. XXI. On the same day (March 19th) at 11 p.m, one drachm of grape sugar syrup, of specific gravity 1,150, was injected under the skin of a frog. At 11 a.m., of the 20th, there was marked opacity of the lens on both sides. The opacity was diffused. The animal was placed in a bed of moist moss, and at 11 a.m. of the 21st all the lenticular opacity had passed away.

Exp. XXII. On March 21st, at 11.45 p.m., one drachm and a half of syrup of grape sugar, specific gravity 1,150, was injected under the skin of a frog. At 11 a.m. of the 22nd there was lenticular opacity on both sides. The opacity was confined to the posterior part of the lens. It disappeared in 24 hours, completely, the animal being placed in a bed of moss saturated with water.

Exp. XXIII. On the same day (the 21st), at 11.50 p.m., one drachm and a half of syrup of grape sugar, of specific gravity 1,150, was injected under the skin of another frog. At 11 a.m. of the 22nd there was no trace of lenticular opacity. At this time one drachm more of the syrup was injected. At 7 p.m. there was intense lenticular opacity on both sides. The opacity was general and vision was totally eclipsed. The opacity passed off in two days.

Exp. XXIV. On March the 23rd one ounce of syrup of grape sugar, of specific gravity 1,150, was injected into the peritoneum of a large rabbit, at 10.30 a.m. At 11 p.m. no effect having been produced, one ounce more of the syrup was injected. On the 24th, during the whole day, the animal was depressed and torpid; towards the evening lenticular opacity, was manifest on both sides, and at 9 p.m. it was most distinct. Between 9 and 10 a.m. of the 25th the animal died, apparently in a comatose state. On removing the lenses, they were found opaque, the cloudiness embracing the whole circumference. Centrally the lenses were clear. The peritoneal cavity was empty of fluid and showed no signs of inflammatory lesion; but all the vascular organs were shrunken.

Exp. XXV. On March 23rd, at 12.30 noon, two drachms of syrup of grape sugar, of specific gravity 1,150, were injected under the skin of a frog. The animal was placed in a bed of moss saturated with water. On the 24th no lenticular opacity having been developed, two drachms more of the syrup were injected at 9 p.m., the animal being left as before in a moist bed. On the 25th there was a very slight dullness in each lens, but the animal recovered without any further sign of disease, such opacity as had occurred passing away in a few hours.

Exp. XXVI. On March 23rd, at 1 p.m., two drachms and a half of grape sugar syrup, of specific gravity 1,150, were injected under the skin of a frog. At 11.45 p.m. there was no sign of opacity: one drachm and a half more of the syrup was now injected. On the 24th there were still no cataract. At 9 p.m. two drachms more of the syrup were thrown in. On the morning of the 25th there was some central lenticular opacity, which passed away in the course of the day. This animal was placed, throughout the inquiry in a bed of moistened moss.

Exp. XXVII. On March 23rd, at 1.15 p. m., one ounce and a half of syrup of grape sugar, of specific gravity 1,150, was injected into the peritoneum of a healthy rabbit. On the 24th, no sign of lenticular opacity had showed itself, but the animal was feeble and torpid. At 9 p. m. it was very torpid. Inthe morning of the 25th it was dead. In this instance the lenses on both sides were found quite clear. The peritoneal surface was injected, and the soft organs were shrunken. The bladder contained urine which gave distinct evidence of sugar.

Exp. XXVIII. On March 24th, at 8 p. m., two drachms of syrup of grape sugar, of specific gravity 1,150, were injected under the skin of a frog On the 25th, the animal was well and without sign of opacity of the lens. Two drachms more of the syrup were again injected at 8 p.m. On the 26th there was distinct opacity in both eyes; but it passed away in ten hours and recovery was complete.

Exp. XXIX. Three drachms of syrup of grape sugar, of specific gravity 1,150, were injected under the skin of a frog, at 8 p. m., on March 25th. On the 26th there was dense opacity in the lens of each eye, the dimness being distributed over the whole surface. The animal was placed in moist grass, but the opacity remained perfect for 30 hours; it then began to resolve, and at the end of three days was entirely removed.

Exp. XXX. On March 25th, at 8.5 p.m. three drachms of the syrup, specific gravity the same, were injected under the skin of another frog. On the 26th, at noon, there was central lenticular opacity which reached its maximum at 8 p. m. Next morning the lenses were found quite unclouded.

Exp. XXXI. Still on the 25th, at 8.10 p. m. three drachms of the syrup, specific gravity 1,150, were injected under the skin of another frog. On the 26th, at noon, there was diffused opacity and total eclipse of vision. Two days later, there was little change and I thought the opacity was permanent. However, on placing the animal in distilled water and often changing the water the dimness cleared away : recovery was complete at the end of the fourth day.

Exp. XXXII. Under the skin of another frog three drachms more of the syrup were injected at 8.15 p. m. On the following day there was complete opacity of each lens : the opacity remained six days, but declined each day to entire disappearance.

Exp. XXXIII. Three drachms of the same syrup were injected on March 25th, at 8.30 p. m. under the skin of another frog. Next day there was marked posterior opacity of the lens on each side. The opacity was very distinct, but limited, and was resolved in a few hours.

Exp. XXXIV. A last experiment with the syrup of grape sugar, of specific gravity as before of 1.150, was made on March 25th, at 8.40 p. m., by the injection of three drachms of the syrup under the skin of another frog. On the morning of the 26th, this frog was found dead. There was no opacity of the lens on either side. The body was considerably shrunken.

EXPERIMENTS WITH SYRUP OF MILK SUGAR.

Exp. XXXV. On March 22nd, at 7.30 p. m., two drachms of syrup of milk sugar, of specific gravity 1.120, were injected into the subcuticular dorsal sac of a frog. On the following day no indication of cataract had been presented, and at 9 p. m. two drachms more of the syrup were introduced. On the 25th there was distinct central opacity which remained for two days, but ultimately passed away.

Exp. XXXVI. Two drachms of the syrup of milk sugar, specific gravity as before, were injected under the skin of a frog on March 23rd, at 12.30 p. m. At 10.20 p. m. the lens on each side was clear. One drachm and a half more of the syrup was now injected. On the 24th, at 11 a. m., the animal was found dead: there was double cataract. On removing the lenses, the opacity was found to embrace all the circumference.

Exp. XXXVII. Two drachms of syrup of milk sugar, specific gravity 1.120, were injected under the skin of a frog, at 12 noon, on March 24th. At 9.30 p. m. there being no lenticular opacity, two drachms more of the syrup were injected. At 11 a. m. of the 25th there was dense opacity of both lenses and entire loss of vision. Placed in water, the animal rapidly recovered, and in 24 hours the opacity had cleared away.

Exp. XXXVIII. On March the 25th, at 8 p. m., two drachms of syrup of milk sugar, specific gravity 1,125, were injected into the dorsal sac of a frog. At 8 a. m. on the following day there was perfect double cataract. The opacity was general and of a pearly whiteness. The animal was so placed as to have access to water; the opacity lasted a full week, but then commenced to clear off and had disappeared in thirteen days.

Exp. XXXIX. At 8. 10 p. m., on March the 25th, two drachms of the same syrup were injected under the skin of another frog. The frog was placed under the precise conditions as the one in the experiment preceding. The results were identical.

Exp. XL. Again on March 25th, at 8.10 p. m., two drachms of the syrup were injected under the skin of another frog, the animal being placed with the two already named in experiments XXXIX and XL. The results were day by day, and I may say hour by hour, the same.

Exp. XLI. Lastly for this section, on the same day (25th), at 8.15 p. m., two drachms of the syrup were injected under the skin of another frog which, after injection, was placed with the rest. At 8 a. m. next day there was the common lenticular opacity and total eclipse of vision, but in the course of the day the animal died, its body being much shrunken. On removing the lenses, I found that the opacity included all the circumference and approached the centre more decidedly than in any previous case.

EXPERIMENTS WITH MANNITE.

Exp. XLII. On May 15th, at 2.30 p. m., two drachms of a solution of mannite, of specific gravity 1,060, were injected beneath the skin of a large toad. At 6 p. m. and again at 9 p. m., the eyes were examined and

were found free of opacity. At 10, the injection of two drachms more was repeated. On the 16th, at 11 a.m., there was found distinctly double lenticular opacity. The opacity was at the posterior surface, and concave in outline. On the 17th, the opacity had passed away altogether.

Exp. XLIII. On May 15th, at 2.35 p.m., two drachms of solution of mannite, of specific gravity 1.060, were injected under the skin of a frog. At 5 p.m., the animal was found dead, with double cataract. The opacity appeared to be on the anterior portion of the lenses. Removing the lenses, I found them soft, and opaque in patches; the opacity did not extend to the centre.

Exp. XLIV. On May 15th, at 2.40 p.m., two drachms of solution of mannite, of specific gravity 1.060, were injected under the skin of another frog. At 5 p.m., the animal was very feeble, and there was diffused lenticular opacity on both sides. At 10 p.m., there was a bright spot in the centre of each lens. On the 16th, the animal having been placed during the night in a chamber bedded with moist grass, there was still some opacity in both lenses, but vision was not altogether obscured. On the 17th, the lenses were perfectly transparent.

Exp. XLV. On May the 17th, at 1 p.m., one drachm and a half of solution of mannite, of specific gravity 1,060, were injected under the skin of a frog. On the 18th, at 11 a.m., there was diffused opacity of the lens on both sides. The animal was feeble. It was placed on moist grass with access to water, and on May 19th was well. Cataract did not remain.

EXPERIMENTS WITH LIQUORICE.

Exp. XLVI. On May 16th, two drachms of aqueous solution of liquorice (extract of the glycyrrhiza glabra), the specific gravity of the solution being 1,050, were injected, at 1.15 p.m., into the subcuticular dorsal sac of a strong healthy frog. At 6 p.m., the animal was dead. The liquid was all taken up, but none of the ordinary osmotic changes were developed. There was no trace of lenticular opacity, nor did any such opacity appear within twelve hours after death.

Exp. XLVII. On May 16th, at 1.20 p.m., two drachms of solution of liquorice, of specific gravity 1.050, were injected under the skin of another large healthy frog. At 5 p.m., the animal was dead presenting the same negative effects as in last experiment. Lenticular opacity was neither produced during life nor after death.

Exp. XLVIII. On May 18th, at 2 p.m., one drachm and a half of the solution of liquorice were injected under the skin of a large toad. At 4 p.m., the body was much shrunken; but there was no lenticular opacity. On the 19th, at 11 a.m., the animal was lively and much less shrunken. There was now general opacity in the lens on each side; the cornea also seemed dim. On the 21st the animal was very feeble, and on the 22nd it was dead. On examining the eyes I found that the opacity was much more evident in the cornea in each eye than in the lenses. There were spots of opacity, nevertheless, in both lenses, and it was peculiar that the right lens was apparently greatly enlarged, while the left one was shrunken and

less than half the size of the right. The right lens was also softer in structure and more opaque.

Exp. XLIX. On May 19th, at 4.45 p.m., one drachm and a half of solution of liquorice, of specific gravity 1.040, were injected under the skin of a frog. At 4.45 p.m., the creature was dead without any indication of shrinking of the tissues. There was no trace of lenticular opacity.

EXPERIMENTS WITH SACCHARINE URINE.

On May 24th I received from Dr Lawrance, of Connaught Square, a few ounces of urine derived from a patient suffering from incipient cataract. The urine had a taste distinctly sweet, and a specific gravity of 1,033. It gave a slight indication of grape sugar on application of Trommer's test, but it obviously contained another saccharine compound which did not react to the common sugar test: I should suspect inosite.

Exp. L. After having evaporated a portion of this urine at a gentle heat, until it gave a specific gravity of 1,125, I injected one drachm and a half of it under the skin of a frog, on May 24th, at 10 a.m. The animal soon after the injection became torpid, but continued to live for a period exceeding fourteen hours. At 2 p.m., there was cloudiness of the lens, and at 6 p.m., the lens on each side was densely opaque, the vision being entirely lost. At 12, midnight, the animal was still alive, but on the morning of the 26th it was found dead, the opacity of lens still remaining.

Exp. LI. On May 26th, a little of the sweet urine syrup was reduced, by the addition of destilled water, to a specific gravity of 1,080. One drachm and a half of this syrup were now injected under the skin of another frog. Considerable depression and torpor followed, but without any sign of opacity of lens. At the end of three days the animal died.

Through the kindness of Dr Wiltshire I was enabled, in the latter part of May, to see a patient under his and M. Hancock's care, at Charing Cross Hospital. The patient was a young woman, and at the time of her entrance into the hospital, as well as at the period when I saw her, she was suffering from double cataract together with diabetes. As far as I could ascertain, the symptoms of diabetes had commenced about two years before, following upon a remittent fever: the loss of vision advanced quickly on the diabetes. At the date when I saw the patient with Dr Wiltshire, the specific gravity of the urine was 1,043, and the fluid was rich in grape sugar, but the quantity of urine passed had been reduced by treatment to a considerable extent, being not more than from four to six pints in the twenty-

four hours. The cataractous condition was in both lenses nearly equally distinct. The lenses were of pearly whiteness and seemed large and soft. Vision was not totally eclipsed, the light of a window being distinguishable, but no particular object was definable. I obtained, through the favour of Dr Wiltshire, three pints of the saccharine urine of this patient with which I made numerous interesting experiments : the annexed are representative specimens.

Exp. LII. The specific gravity of the portion of urine which was obtained from the patient for my own experiments had a specific gravity of 1,040. On June 2nd, at 6 p. m., one drachm and a half of the urine were injected under the skin of a frog. At 12 p.m., the animal was unaffected, and there was not the least indication of the cataractous state. One drachm and a half more were now injected. At 10 a.m., on June 3rd, there was slight opacity of the lens on each side : it was a diffused milkiness and so faint that loss of vision did not seem to result. Another drachm and a half of the urine were now injected and, in the course of 6 hours the lenticular opacity was much further developed. The opacity lasted for two days, but gradually passed away leaving vision again perfect.

Exp. LIII. A portion of the same urine was gently evaporated until it gave a specific gravity of 1.060. On June the 5th, at 7.30 p.m., one drachm and a half of the urine thus treated were injected under the skin of a large frog. On June 6th, at 11 a.m., the animal was found lively with slight opacity of both lenses. On the 7th, at 11 a.m., the opacity having passed away, one drachm and a half more of the urine were injected. At 7 p.m., there were all the symptoms of sugar poisoning with distinct opacity of both lenses. On the 8th, at 11 a.m., the animal was found dead, the lenses still remaining opaque.

Exp. LIV. On June 8th, another portion of the same urine was evaporated to a specific gravity of 1.100. At 12.30 p.m., one drachm and a half of this solution were injected under the skin of a large frog. At 4.30, the animal was found dead, the body much shrunken, and the surface of the skin very dry. There was opacity of each lens. The result was less marked than in previous instances.

Exp. LV. On the same day, at 2 p.m., one drachm and a half of the diabetic urine, brought by evaporation to a specific gravity of 1,150, were injected under the skin of another frog. At 4.30 p.m., this animal was also dead, with the body greatly shrunken and intense opacity of the lens in each eye.

Exp. LVI. On June 10th, at 9 a.m , one drachm of the urine, brought to a specific gravity of 1.200, was injected under the skin of another frog. The animal passed through all the symptoms of sugar poisoning, and died about 3 p.m. The cataractous condition was again markedly brought out.

On various other occasions I repeated these experiments

with the saccharine urine : the results were entirely corroborative of those already given. Three experiments with this urine I had the honour of performing at Bedford, on June 15th, before the members of the South Midland Branch of the British Medical Association. The success of the experiments was complete.

From the researches with sugars, thus recorded, I pass to others bearing on the action of bodies more or less analogous to the saccharine series.

EXPERIMENTS WITH GLYCERINE.

Exp. LVII. One drachm of pure glycerine was injected beneath the skin of a frog on April 11th, at 3.15 p.m. At 6 p.m., the animal was lively, but there was distinct posterior opacity of the lens on both sides. The animal contrived to escape and was not seen again.

Exp. LVIII. On April 12th, at 12, noon, one drachm and a half of glycerine were injected under the skin of a frog. In this instance, and the same occurred in the last experiment, the injection ran with much difficulty. At 6 p.m., the animal was dead. There was no indication of change of the lens.

Exp. LIX. On May 19th, at 2 p.m., one drachm and a half of water solution of glycerine, of specific gravity of 1.060, were injected under the skin of a frog. At 5 p.m., the animal was very languid, and there was slight general dullness of the lens of each side. The animal died on the following day. The opacity of the lens was at no time very strongly evidenced.

Exp. LX. On May 19th, at 2.5 p.m., half a drachm of solution of glycerine, of specific gravity 1.100, was injected under the skin of another frog. At 5 p.m., there was great prostration and feeble muscular irritability. There was not the slightest dullness of the lens. At 6 p.m., the animal was suffering from distinct tetanus. The tetanic attacks were intermittent and could be excited by the merest excitation after intervals of rest ranging from three to five minutes. At 6.30, the animal was placed in water charged with nitrous oxide. The convulsions abated, but death occurred in half an hour from the narcotic effects of the solution. The opacity of the lenses was very slight indeed.

EXPERIMENTS WITH ALCOHOL.

Exp. LXI. On April 11th, one drachm of absolute alcohol was injected under the skin of a large frog at 6 p.m. At 8 p.m., the animal was dead with the most extraordinary shrinking and collapse I have seen. There was posterior lenticular opacity on both sides.

Exp. LXII. Half a drachm of absolute alcohol was injected under the skin of another frog on April 11th, at 12 m. At 6 p.m., the animal was dead with great collapse of the body and dryness of the surface. There was well marked opacity of the lens on the right side. The lens on the left side was clear. There was no further opacity produced after death.

Exp. LXIII. On May 21st, at 1 p. m., 20 minims of absolute alcohol, mixed with 40 minims of water, were injected into the subcuticular dorsal sac of a large frog. At 2 p.m., the animal was dead with great collapse of the tissues. Preceding death there were occasional convulsions of the posterior extremities; the convulsions could be excited by pricking. There was no sign of lenticular opacity either before or after death.

Exp. LXIV. At 1.5 p.m., on the same day, 15 minims of absolute alcohol with 45 of water were injected under the skin of another large frog. At 2 p.m., the animal was dead with intense collapse. The death, as in the previous case, was preceded by convulsions: there was no opacity of the lens.

Exp. LXV. On May 21st, at 1.10 p.m., 5 minims of absolute alcohol with 25 minims of water were injected under the skin of a frog. At 2 p.m., the animal was dead. There was in this case no convulsions, but collapse was not less manifested. There was no indication of lenticular opacity.

Exp. LXVI. On the same day and at the same time five minims of absolute alcohol with 25 minims of water were injected under the skin of another frog. This and the previous animal were placed in precisely similar conditions. At 2 p.m., the animal was still alive, but very feeble. At 3 p.m., it was alive. At 5, it was recovering from the prostration. The animal ultimately recovered, giving no indication of opacity of the lens.

These experiments complete the history, as far as I have yet learned it, respecting the influence of the saccharine series and the allies of that series. There is one other direction in which the subject deserves to be followed out: it would be important to institute similar enquiries, to those already given, with *inosite*. As yet, I have been unable to make or obtain a sufficient quantity of this sugar for experimental purposes. I am obliged, therefore, unwillingly to pass over this line of enquiry and to proceed to illustrate the effects of soluble saline substances in the production of the artificial cataract.

EXPERIMENTS WITH SALINES.

Exp. LXVII. On April 10, at 4 p. m., three drachms of a solution of chloride of sodium, of specific gravity 1.150, were injected under the skin of a large frog. The creature became immediately tetanic. The limbs were drawn up forcibly to the body, and in twenty minutes the whole body was fixed; at the same time there was a constant and general twitching of the muscles, — jactitation — which continued actively for an hour, although the animal itself seemed to be really dead. Previous to death, indeed within fifteen minutes after the injection, there was opacity of the lens on both sides and the lenses assumed a denseness and a peculiar whiteness such as I had not before seen. The appearance was more like that of a lens which had been subjected to boiling than aught else. On removing the

cornea, I found it clear, and the parts surrounding the lenses also clear. On making section of one lens, it cut firmly, and the opacity was extended throughout its structure, from the circumference to the centre. The other lens, submitted to water, became soft in structure, but not clear.

Exp. LXVIII. On April 10th, at 4.15 p. m., two drachms of a solution of chloride of sodium, of specific gravity 1.150, were injected under the skin of another frog. The animal was immediately convulsed, and in twenty minutes was tetanic. Death occurred in a little more than an hour after the operation, jactitation of the muscles continuing to the last. The opacity of the lens on each side commenced within half an hour after the injection, and continued rapidly to increase to total eclipse of vision. The change in the lens was identical with that which had been observed in the experiment immediately preceding.

Exp. LXIX. On April 10th, at 5 p. m., one drachm of solution of chloride of sodium was injected into the subcuticular dorsal sac of a frog. The animal remained quiet for 30 minutes; then it was violently convulsed the convulsions ending in rigid tetanos. Death did not occur, however, for two hours, during the whole of which period there was constant jactitation of the extensor muscles. The opacity of the lens on both sides was well marked within twenty minutes after the injection and progressed rapidly. The opacity was of the same intense kind as in the two experiments immediately preceding.

Exp. LXX. On April 11th, at 2.30 p. m., half a drachm of solution of chloride of sodium, of specific gravity 1.150, was injected under the skin of a frog. At 10 minutes to 4 p. m., the animal was entirely collapsed and scarcely alive. There was opacity of the lens of each eye : in one lens the opacity was diffused, in the other it was situated posteriorly only, and in a single point. The animal died within the hour.

Exp. LXXI. On April 16th, at 7.30 p. m., one drachm of a solution of chloride of sodium, of specific gravity 1.100, was injected under the skin of a frog. Tetanic symptoms occurred within an hour after the injection, and were very severe. They subsided before death. Two hours after the injection, dense lenticular opacity on both sides was produced. After death, on removing the lenses, they cut firmly and showed an opacity extending to the centre.

Exp. LXXII. On April 11th, at 3.30 p. m., one drachm of a solution of chloride of sodium, of specific gravity 1.050, was injected under the skin of a large frog. At half past four, the animal was moving about very actively without convulsion and with but little collapse. There was now distinct double cataract. At 6, the animal had a peculiar dark, dry, and as it were varnished condition of the skin; the prostration was very great : there was total eclipse of vision, and the eyes looked like two pearl spots fixed in the head. The animal was now placed in a vessel containing water, its body being half immersed in that fluid. The water was changed about every six hours. On the 12th of April, the animal was much better : the shrinking had almost entirely passed away, and the density of the lens on each side was diminished. In the evening of this day the only visible opacity was on the posterior surface of the lens. On the 13th, the animal

seemed as lively as ever, and the lens of each eye was purely transparent.

Exp. LXXIII. On April 14th, at 1 p. m., one drachm of solution of chloride of sodium, of specific gravity 1.050, was injected a second time beneath the skin of the frog used in last experiment. At 4 p. m., the lenticular opacity was developed on both sides, but not intensely. The animal was now at once placed in water which was frequently changed. The effect of the water was to arrest at once the progress of the change in the lens. On the 14th, early in the morning, the lenses were quite restored to transparency, and on the day following the animal was well.

Exp. LXXIV. On April 18th, at 1.30 p. m., one drachm of solution of chloride of sodium, of specific gravity 1.050, was injected into the dorsal sac of the same frog as was used in the last experiment. At 6 p. m., there was distinct opacity of the lens on each side, and at 12, vision was totally obscured. The animal was again placed in fresh water, and in twelve hours there was complete restoration of sight and transparency of the lenses.

Exp. LXXV. On April the 28th, the frog already experimented on in the three last named experiments, and having recovered so as to seem in perfect health, was subjected a fourth time to injection. One drachm and a half of solution of chloride of sodium, of specific gravity 1.050, were introduced under the skin as before. In six hours there was developed posterior lenticular opacity, which caused entire loss of vision. The opacity then became diffused through the lens altogether; but it passed off rapidly on the animal being supplied with fresh water. Early on the morning of the 29th, the lenses were again perfectly clear.

Exp. LXXVI. On May 5th, one drachm and a half of the chloride of sodium solution, of specific gravity 1.050, were injected again under the skin of the frog referred to above, at 2 p. m. Within the hour after the injection there was central opacity of both lenses. At 11 p. m., the eclipse of vision was total and the lenses of pearly whiteness. The animal was now placed in fresh water, and at 9. a. m. of the 6th, each lens was partially clear in the centre, but of dense opacity in the circumference. At 12 noon, the water supplied to the animal having been often changed, there was nothing left but slight posterior opacity; at 3 p. m., each lens was entirely transparent.

Exp. LXXVII. On May 11th, at 2 p. m., the frog above named was injected for the last time with the saline solution. At 2 p. m., two drachms of solution of the chloride of sodium, of specific gravity 1.050, were injected under the skin. In two hours there was posterior opacity of the lens in both eyes. On the 12th, there was the same condition of the eyes. The animal was now languid, and although it was less shrunken than in any previous experiment, it was feebler. The skin was covered with dark patchial spots, and blood exuded from the feet giving a deep red colour to the water by which the animal was surrounded. On the 13th, there was no remaining opacity of the lens, but great feebleness of body. Without much sensible improvement, the animal lived on until the first Sunday in June, when it was found dead. After death I removed the lenses: they exhibited perfect transparency.

Exp. LXXVIII. On April 18th, my friend, Mr Miller, of Bethnal Green

House, took the trouble to place a pig under experiment for me. The notes of the experiment were made, and the details were most carefully drawn out by Dr Ritchie. The pig, at the commencement of the experiment, was in good health. He was placed alone in a sty, and was fed on the ordinary food for fattening these animals. A solution of common salt having been made, consisting of two ounces of salt in six ounces of water, one ounce of the solution was added to the food each day from the 18th to the 24th. From the 24th to the 30th, one ounce and a half of the solution was given. Up to this time, it was observed that the animal, although taking food as usual, did not improve in condition. The crystalline lens on each side continued clear. On May 1st, the dose of the salt solution was increased to four ounces daily, and on the 3rd to six ounces. On the 7th, four ounces of undissolved salt were added to the food, and this was continued until the 11th. On the 12th, six ounces of the salt were added to the food, and this quantity was continued daily until the 19th. The animal ate his food well and showed no sign of being affected by it. About the 11th, Dr Ritchie thought there was some lenticular dullness, but this effect soon passed off. The skin also remained free of blotches, and the strength of the animal remained as usual. The only change that could be observed was that he did not increase in weight and fatness, like other animals fed at the same time and place, on the same kind of food without the common salt.

EXPERIMENTS WITH CHLORIDE OF AMMONIUM.

Exp. LXXIX. On May 22nd, at 2 p.m., one drachm of a solution of chloride of ammonium, of specific gravity 1.060, was injected under the skin of a large frog. At 2.15, the animal was prostrate; its skin was dry, and there was constant jactitation of its muscles. There was already dullness of the lens on each side. At 2.30, the animal was incapable of movement, and in a few minutes later it was dead. On removing the lenses after death, I found them firm and densely opaque.

Exp. LXXX. At 2 p.m., on June 23rd, half a drachm of a solution of chloride of ammonium, of a specific gravity 1.060, was injected under the skin of a frog. Within twenty minutes there was great prostration, dryness of skin and commencing lenticular opacity. In half an hour death had occurred. On removing the lenses, they were found entirely opaque and resembling pearl beads in appearance : they cut firmly.

Exp. LXXXI. At 2.10 p.m. of the same day, fifteen minims of the solution of chloride of ammonium were injected under the skin of another frog. The effects in this case were in the end the same as in the last, but the animal lived longer, death not taking place for two hours. Previous to death, the lens of each eye was of pearly whiteness, and vision was altogether eclipsed. On removal, both lenses were opaque throughout their entire structure.

Exp. LXXXII. On the same day, at 2.45 p.m., twenty minims of chloride of ammonium solution, of specific gravity 1.060, were injected under the skin of a frog. Twenty minutes after the injection, the animal was dead : the body was much shrunken, and the surface had a dry and

glazed aspect. Previous to death, there was double lenticular cloudiness which increased to pearly whiteness and opacity after death.

EXPERIMENTS WITH CHLORIDE OF POTASSIUM.

Exp. LXXXIII. On May 23rd, at 2.30 p.m., twenty minims of a solution of chloride of potassium, of specific gravity 1.060, were injected under the skin of a frog. At 2 p.m., the animal was dead. The body was not much shrunken, but there was slight opacity of the lens on both sides. In one lens the opacity was diffused, in the other it was confined to a single point in the posterior surface of the lens.

Exp. LXXXIV. On the same day, at 2.35 p.m., fifteen minims of solution of chloride of potassium, of same specific gravity, were injected under the skin of another frog. At 3.15, the animal was dead. There was opacity of each lens, but it was not very marked.

Exp. LXXXV. At 2.40, again on the 23rd of May, ten minims of the solution of chloride of potassium were injected under the skin of a frog. The animal was small, and the effect of the saline was very rapid. Within fifteen minutes death had taken place without any appearance of lenticular opacity previous to death.

EXPERIMENTS WITH LACTATE OF SODA.

Exp. LXXXVI. On April 16th, at 7.30 p.m., two drachms of a solution of lactate of soda, of specific gravity 1.060, were injected into the subcuticular dorsal sac of a large frog. At the end of four hours the animal died, but with much less of shrinking of the tissues than had been observed in other cases. There was slight opacity of the lens posteriorly.

Exp. LXXXVII. On June 8th, at 12.15 p.m., one drachm of a solution of lactate of soda, of specific gravity 1.060, was injected under the skin of frog. At 4 p.m., there was a commencing opacity of the lens posteriorly. At 6, there was well marked opacity. The opacity lasted about nine hours. On June 9th, lenses were quite clear and the animal seemed well.

Exp. LXXXVIII. On the same day, at 12.10 p.m., one drachm and a half of solution of lactate of soda, of the same specific gravity, were injected under the skin of another frog. In four hours, there was exhibited, with but little prostration of body, a commencing posterior point of opacity in each lens. At 6 p.m., this opacity was well marked : it was confined to the posterior surface. Early in the morning of June 9th, the animal was well, and both its lenses were clear as before the experiment.

EXPERIMENTS WITH CARBONATE OF SODA.

Exp. LXXXIX. On June 7th, at 11.35 a.m., one drachm of a solution of carbonate of soda was injected under the skin of a frog. At noon, the body of the animal was greatly shrunken and the lens on each side was densely opaque over the whole surface anteriorly. At 5 p.m., the animal was scarcely living; it was placed in water, bud did not recover, and

at 7 p.m. was dead. Previous to death the opacity of the lenses had considerably diminished.

Exp. XC. On the same day, at 11.40 a.m., one drachm and a half of the solution of carbonate of soda, of specific gravity 1.060, were injected under the skin of another frog. At noon, there was great shrinking of the tissues and double lenticular opacity. At 5 p.m., the animal was still alive, but nearly motionless. The opacity of the lenses had almost disappeared. Partly immersed in water, the animal did not recover; it died about two hours after the immersion, the lenses becoming entirely clear.

EXPERIMENTS WITH PHOSPHATE OF SODA.

Exp. XCI. A saturated solution of phosphate of soda, of specific gravity 1.045, having been made, one drachm and a half of the solution were injected under the skin of a frog, on June 9th, at 3.10 p.m. At midnight, the animal was living and active. There was no opacity of the lens. On June 10th, at noon, the animal was well.

Exp. XCII. On June 9th, at 3.15 p.m., one drachm and a half of the solution of phosphate of soda were injected under the skin of another frog. At midnight, the animal was dead with the body much shrunken. There was no indication of opacity in either lenticular body.

Exp. XCIII. On June 11th, two drachms of the same solution of the phosphate were injected under the skin of a frog, at 2.15 p.m. At 5 p.m., the animal was dead with much shrinking of the body. There was again no indication of opacity of the lenses.

EXPERIMENTS WITH CARBONATE OF POTASSA.

Exp. XCIV. On June 5th, at 7.30 p.m., one drachm and a half of a solution of carbonate of potassa, of specific gravity 1.060, were injected under the skin of a large frog. At 9 p.m., the animal was dead: there was intense shrinking of the body, and well marked opacity of the lens in both eyes. The opacity was diffused.

Exp. XCV. On June 7th, at 11 a.m., one drachm of a solution of carbonate of potassa, of specific gravity 1.060, were injected under the skin of another frog. Death occurred within two hours with considerable shrinking of the tissues, but this time without the appearance of cataract. The lenses were perfectly transparent at the time of death, and remained so twelve hours afterwards. Removed from the eyes, they were found beautifully clear.

EXPERIMENTS WITH SULPHATE OF POTASSA.

Exp. XCVI. On June 7th, at 11.45 a.m., one drachm of a solution of sulphate of potassa, of specific gravity 1.060, was injected under the skin of a frog. The injection was followed speedily by rapid collapse and death within an hour. The lens on each side assumed, previously to death, a milk white opacity; but after death this passed away, the animal having

been placed in the same position as before death. Five hours after death, the lenses of both eyes were purely transparent.

Exp. XCVII. On the same day, one drachm and a half of the solution of sulphate of potassa, of specific gravity as before, were injected under the skin of another frog. Death again occurred within the hour with marked opacity of the lens. As in the experiment preceding, there was a clearance of the opacity after death, although the body of the animal was not exposed to water.

EXPERIMENTS WITH SERUM OF BLOOD.

In the above experiments I have included observations on all the simple soluble saline substances that may be considered as connected with the blood. I afterwards performed some further experiments with serum of blood itself. I will mention one or two of these to make the narrative complete.

Exp. XCVIII. Three quarts of mixed blood were drawn from the throat of an ox at the slaughter-house. The blood was set aside for separation of serum. When the serum had so separated that it could be drawn of with a syphon a few ounces of it, of a straw colour, were removed. The fluid had a specific gravity of 1.035 and a saline taste. Two drachms of the fluid were injected under the skin of a large frog, and the animal was observed every hour for the succeeding twelve hours. There was no shrinking of the body and no sign of lenticular opacity. It seemed to me that the animal was nourrished by the injection, for placed in a well dried glass globe, it retained its liveliness and moisture for many hours.

This experiment, on repetition, gave similar results.

Exp. XCIX. Six ounces of the serum of the same blood were next removed and placed in an open dish on the water bath. Very gentle evaporation was now slowly carried on, the heat never being allowed to rise to the extent of coagulating the albumen. In this way I obtained a solution having a specific gravity of 1,043. I observed that by continuing the evaporation beyond this point, there deposited a dirty, gritty precipitate, after the occurrence of which the specific gravity of the fluid began to fall. I took therefore the fluid at a specific gravity of 1,043, and injected two drachms of it under the skin of a frog. There was no shrinking of the body induced, neither was there any lenticular opacity. The animal, as in the previous case, appeared to be nourrished by the fluid.

A repetition of the experiment led to like results.

Exp. C. I drew off thirty ounces of serum from the same blood, and, placing it in a beaker, put it on the water bath, and applied heat until the albumen had coagulated. The jelly like mass was now thrown on a cloth

filter, and the watery part extracted by gentle compression whilst the fluid was still hot. The fluid expressed was again exposed to heat, and some remaining flakes of albumen were filtered off. When the fluid had cooled to 60° Fahrenheit, it was found to have a specific gravity of 1.016. It was now placed in a water bath and evaporated. By evaporation this saline solution could be brought to 1.043, after which further evaporation caused a dirty precipitation and a decline in specific gravity. Two drachms of the evaporated solution at 1.042 were injected under the skin of a large frog, and the animal was observed from hour to hour until death: it died nine hours after the injection with some skrinking of the body, but with no opacity of the lenses.

The experiment was repeated on another frog with results nearly identical, perhaps quite. I cannot however state positively the hour of death of the second frog: three hours after injection it was fully alive, and ten hours afterwards it was dead. The body was shrunken, the lenses were clear.

EXPERIMENTS WITH ACID URATE OF SODA.

Urate of soda is so little soluble that it could not be expected, *à priori*, to produce any decided effet. Nevertheless, I made two experiments with it to test if it would be absorbed by the living surface.

Exp. CI. Four drachms of acid urate of soda were placed in four ounces of water thickened with a little gum arabic: by brisk stirring the salt could be suspended for a brief period. On April 11th, at half past four p. m., one drachm of this mechanical solution, after brisk agitation, was injected beneath the skin of a frog. On the following day, there had been produced no effects. One drachm and a half more were therefore injected. Next day, the result being still negative, another drachm and a half were injected. On the succeeding morning the animal was as well and as lively as ever. One drachm more was introduced under the skin, and the same quantity was given by the mouth. In the evening the animal seemed quite well, but next morning it was found dead without any collapse or opacity of the lens. When the skin was removed from the body no sign of the powder of the urate was discernible. The lenses on each side were perfectly clear.

Exp. CII. On April 11th, a second frog was placed under the same experiment with the acid urate as the one preceding. The administration of the urate was also repeated at the same periods and in the same quantities. The results were alike until the morning of the 15th, when the frog named in last experiment was found dead whilst the present one was living and as active as ever. The experiment on this latter frog was continued three days more, but without result, the lenses always retained their clearness.

As bearing on these experiments with urate of soda, I may mention incidentally the following circumstance : On March the 2nd of the present year, a bitch, that had been fattened to the fullest extent, was ordered per day, with her food, night and morning, one drachm of acid urate of soda with each meal. The object looked for was the occurrence of gouty symptoms from the treatment. She took the urate without compulsion, and after a week it was increased to *two* drachms at each meal. She continued thus under treatment for fifteen weeks, at the end of which period she had consumed altogether 384 drachms or 1 pound avoirdupois of the urate salt.

During the whole of this period, the animal retained her plethora and showed no sign of gout nor of swelling in the limbs; but it was obvious, in April, that she was becoming blind. The eyes through the pupil were opaque looking, and the animal ceased to discern objects, even those near to her. During May she seemed to be quite blind and continued so until the urate was stopped, since which time she has recovered, and now sees as well as ever.

My friend, Mr. Wordsworth, was kind enough, in this case, to aid me in examining the eyes of the animal with the ophthalmoscope. At the time of the examination the animal was beginning to see again a little. Our observations, contrary to my previous opinion, but in accordance with Mr. Wordsworth's, proved that the lenses were clear, and that the disease was in the retina, consisting of white discoloration of the retina. One lens presented the merest nebulosity; but there were no isolated opacities, and the vessels of the retina could be distinguished plainly.

EXPERIMENTS WITH SALINE SUBSTANCES FOREIGN TO THE BODY.

Exp. CIII. On April 20th, one drachm and a half of a solution of *chloride of calcium*, of specific gravity 1,060, were injected under the skin of a frog at 5 p. m. The animal died six hours after the operation with much shrinking of body and with marked lenticular opacity on both sides. There was no tetanic spasm antecedently to death.

Exp. CIV. On June 13th, one drachm and a half of a solution of *chloride of barium*, of specific gravity 1,060, were injected under the skin of a frog at 7 p. m. At 8, the animal was collapsed and the lens of each eye was becoming opaque. At 9, the lenses were densely opaque and like pearls.

At 10 p.m., the animal was dead. Tetanus did not occur before death. This experiment was repeated next day on another frog with the same occurrences, identically.

Exp. CV. On April 15th, one drachm and a half of a solution of *iodide of potassium*, of a specific gravity 1,060, were injected under the skin of a large healthy frog at 20 minutes after 1 p.m. The animal began to shrink within 10 minutes after injection, and the limbs were convulsed. At 3 p.m. death had taken place. The body was intensely collapsed, but there was not the slightest change in the lens on either side. No opacity occurred after death.

Exp. CVI. On the same day, at 5 minutes to 2 p.m., fifteen minims of the solution of *iodide of potassium*, of specific gravity 1,060, were injected under the skin of another frog. At 3 p.m., the animal was living, but was intensely shrunken and collapsed. At 5, the creature was dead. Neither before nor after death was there any indication of opacity of the lens.

Exp. CVII. On the same day, at 20 minutes past 9 p.m., fifteen minims of a solution of the *iodide of potassium*, of specific gravity 1,050, were injected under the skin of another frog, with 45 minims of water. Within two hours there was, as before, great shrinking and convulsion; death took place within six hours, but there was no lenticular change.

In addition to the experiments on living animals, I made experiments with the same solutions on the eyes of animals recently killed. In one series of enquiries conducted in this direction, the fluids were injected with a fine hollow needle into the aqueous chamber. In another series the lenses were removed and immersed in the solutions. It is not necessary to say more, respecting these lines of research, than to add that, although the results were in the main the same as in the experiments on living animals, the effects were much more slowly developated, and the changes produced were less intense.

EXPERIMENTAL SUMMARY.

A few words in the way of comment must conclude this communication. In the first place it is to be observed that the success of the experiment in producing the cataractous condition turns on the specific gravity of the fluid injected. It required in every example that the specific gravity should exceed 1,045, in other words that it should exceed the specific gravity of the blood. But so soon as a condition of the blood was obtained, so soon as the circulating fluid could afford secretions, having an abnormal density, then the cataractous change was induced, and lasted so long as the blood retained its abnormal state.

This fact was further brought out by those experiments in which the opacity of the lens was either quickly removed or was prevented altogether by the immersion of the animal in water.

The fact was further supported by the general effects of the dense fluid on the tissues of the body. There was scarcely a case in which the lenticular opacity was strongly marked in which there was not therewith a shrinking of the tissues, followed in most cases by convulsion, amounting even to tetanus.

The sugars and the salines alike produced the specific effect, with one remarkable exception, I mean the exception offered in the experiments with the iodide of potassium. This salt, while it caused more intense general collapse perhaps than any other, left the lens unaffected in every case. I do not pretend to explain this curious and remarkable fact.

The mode by which the cataractous state is produced must be accepted, I think, as osmotic in character : i. e. as a direct physical effect on the lens through its surrounding and internal fluids, by which the arrangement of the lens fibres or tubes is changed. I have confirmed the observation of Dr. Mitchell that this effect is distinct from that of mere exsiccation.

Of the changes which occur in the structure of the lens from these experiments, my observations run parallel with those of Drs. Mitchell and Hunt; I differ with them only on one point, viz. as to the spot where the opacity commences in all cases. They observe that the opacity begins upon the posterior surface of the lens, and this accords with the majority of my own observations; but in a few cases I have seen it commence on the anterior surface; these are however exceptions to the rule. I am at one with the above named authors, also, in believing that the capsule of the lens remains clear, while the microscopical peculiarities that are presented I cannot describe in more terse and truthful terms than by borrowing Dr. Mitchell's exact description : "When such a lens (meaning a lens rendered opaque by sugar) is viewed under a low power, in place of the faint indication of the track of the lens fibres which is usually seen, the line of cleavage is unduly distinct, and the fibres setting out from it are edged with dark irregular lines, marking interlocking with neighbouring fibres. A good deal of granular matter is also dispersed through the preparations. In some advanced

cases the fibres or tubes are enlarged irregularly, and their interior contents escaping are seen abundantly in the form of yellowish pellucid globules about the tubes and throughout the field of view." These remarks apply to sugar cataract; in extreme saline cataract the fibres or tubes of the lens are entirely disorganized.

I proved in some cases of grape sugar cataract the existence of the sugar itself in the lens. By removing four of these lenses, at the stage of complete obscurity, and by macerating them, I obtained the most perfect reaction for sugar from the solution by Frommer's test.

There is seen after many observations a difference in general character between the artificially induced sugar and saline cataracts. The sugar cataract is large, soft and pearly white. The saline cataract, in its intensest form, is rather shrunken and is firm in structure, but is of the same whiteness. The effects of different soluble substances are neither precisely alike in the matter of time nor intensity, even when used of one density. Thus both the cane and the milk sugars produce the cataractous condition much more readily and permanently than grape sugar. The milk sugar produces, in its turn, a less rapid, but a more permanent effect than the cane sugar. Amongst the salines, the chlorides act most energetically; after these the sulphates.

The rule was almost one to the effect, that when the opacity of the lens was produced before death, the opacity also remained or even became more intense after death. To this rule, there was a striking exception, viz. that the opacity produced by the sulphate of potassa disappeared altogether after the animal was dead. I do not see any satisfactory explanation of this occurrence.

ON THE RELATIONS OF THE ABOVE RESEARCHES TO CATARACT IN THE HUMAN SUBJECT.

As no synthesis could be more perfect than that of cataract, it is impossible not to see that a relationship exists between the artificial and the natural disease. In reference to sugar cataract, this view is strengthened by the acknowledged connection existing between cataract and diabetes. This connection

was known and taught years ago by Dr. Craigie, of Edinburgh, but it has remained for Mr. France in this country, and Günzler, Hastner, Arlt, and especially Von Gräfe on the Continent, to point out from clinical history, but without any physiological basis, the absolute fact of this connection. Von Gräfe, I believe, has stated that one fourth of diabetic patients are affected with cataract. I can give no statistical facts on this point, but that the connection is very common is certain, from the circumstance that, since my first communication on the synthesis of cataract was made in April last to the MEDICAL SOCIETY OF LONDON, no less than seven cases have been brought before my notice in which there was diabetes with well marked lenticular opacity. It is further known, I find, that in diabetic cataract, the aqueous humour is often charged with grape sugar. We may thus consider that the analytical together with the synthetical method of research show not only that the two diseases, diabetes and cataract, may coexist, but that the cataractous condition, in cases where such coexistence is present, is proved to depend on a common constitutional disorder, an excess of sugar in the organism, and on the interference, as a consequence, with the nutrition and normal construction of the lens. That diabetes should be present without cataract in many cases is in no way opposed to this conclusion; for if the sugar made in the economy is passed off by the urine in proportion to its manufacture, then it will not find its way into other secretions and cataract need not result. We must rather look for diabetic cataract, in fact, in cases where, with the existence of sugar in excess in the economy, the outward sign of the diseased condition, profuse diuresis, is deficient or absent.

Neither must we, in fairness, confine ourselves to the mere idea of sugar cataract from osmotic cause. It must be remembered as the primitive fact, not only that the increase of the specific gravity of the fluids of the eye by *sugar* will destroy the refracting power of the lens, but that, whatever soluble substance will increase the specific gravity of the fluids, will induce the same condition. There may be thus saline cataract as well as diabetic.

Nor again must we confine ourselves to the idea of a *cataractous* condition of the eye-ball in considering osmotic changes in the ocular structures. It is probable that with an opposite

condition of the natural fluids of the visual organ, I mean with a reduced specific gravity, an opposite disease would result, in which the refracting bodies of those fluids, without losing their clearness, but assuming a new tint, would be disorganized by excessive transudation (endosmosis) and distention. All this has to be looked into by the student of ophthalmic science.

Lastly, and returning to the diabetic state, the effect of this on the retina has to be considered. In two cases of diabetes with loss of vision which I have seen and in which I detected whiteness deep in the ball of the eye, the eye, on being examined by the ophthalmoscope, has given no sign of lenticular disorder, but evidence of a change in the retina : whiteness by which a reflecting surface has been offered that has given to the eye, under common observation, the appearance of cataract without the fact. In one patient, my colleague, Mr. Spencer Wells, was good enough to examine the eye with me, and determined definitely that the disease was in the retina ; in the second case I was able not only to come to this decision before death, but to find, after death, that the lens and vitreous humour were clear, and that the mischief was in the retina.

These simple synthetical researches have a deep hold in practice. If physiologists can and will go on developing them, what will the world say of physic as a science in half a century hence? A science then *without a method*, when all disease shall be put on a physical (including chemical) basis and demonstration? I think not. At all events I, for one, looking into time, can laugh at the scorners, and go my way, knowing that he who refuses to work in this field gives me the more treasure.

PARIS. — IMPRIMERIE DE J. CLAYE, RUE SAINT-BENOIT, 7.